The Specific Heats, C_{σ} , and C_{V} , of Compressed and Liquefied Methane*

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The specific heats, C_{σ} , of saturated liquid methane have been measured at 66 temperatures in the temperature range 95–187 K. The specific heats at constant volume, C_V , have been measured at 20 densities ranging from 0.8 to 2.8 times the critical density, at temperatures between 91 and 300 K, and at pressures to 330 bar (at 280 PVT states in all). The uncertainty of most of the measurements is estimated to be less than 0.5 percent, except near the critical point. These measurements were performed primarily to provide input data for accurate thermodynamic properties data calculations for liquid methane. They are believed to be the most comprehensive specific heat measurements available for pure compressed gaseous and liquid methane.

Key words: Constant volume; heat capacity; liquid; saturated liquid; specific heat; methane.

1. Introduction

For the calculation of fluid thermodynamic properties such as internal energy, enthalpy, entropy, and velocity of sound, at temperatures less than the critical point, one needs either the latent heat of vaporization or specific heat along a path traversing the temperatures of interest. Heat capacity measurements are much easier than latent heat measurements and the specific heat measurements are not restricted to the liquid-vapor curve but can be made covering temperatures and densities in the single phase fluid region as well.

For methane, specific heat of the saturated liquid, C_{σ} , was measured from 95 to 187 K, and specific heat at constant volume, C_{V} , was measured on 20 isochores with densities ranging from 8 mol/l to 28 mol/l, temperatures from 90 to 300 K, and pressures to 330 bar [1].¹

2. Apparatus

The specific heats were obtained using a constant volume adiabatic calorimeter, as described previously by Goodwin [2]. Basically, it consists of a thin spherical stainless-steel sample holder bearing a heater and platinum resistance thermometer and enclosed in an adiabatic shield. The calorimeter and cryostat are shown in figure 1. The refrigerant was liquid nitrogen.

The versatility of this instrument is demonstrated in that it has been used with very minor modifications for the C_V and C_σ measurements of hydrogen [3, 4], oxygen [5, 6], fluorine [7, 8], and in this work on methane. These measurements cover temperatures from 14 to 300 K and pressures to 330 bar.

The thermometer was calibrated by the NBS Temperature Section. Temperatures are on the IPTS-68 scale. The temperature of the adiabatic shield and guard ring are controlled to the sample temperature with difference thermocouples and automatic power regulation. Heat exchange to the sample holder is considered negligible.

The sample used was 99.99 percent methane. Impurities as analyzed by the supplier in ppm were $CO_2 < 10$; O_2 , 4; N_2 , 12. A molecular sieve in an ice bath served to ensure removal of water vapor present in the sample.

3. Procedure

In essence, the specific heat C_V is calculated from the measured parameters as follows. The total heat capacity is determined as the ratio of the heat input ΔQ to the temperature increase ΔT brought about by applying a very stable power source to a resistor attached to the calorimeter sample holder, for an elapsed time Δt . The heat capacity of the empty sample holder Co is then subtracted off. It, of course, was previously measured in exactly the same way except with the sample space pumped to a vacuum. The difference of these two quantities is the heat capacity of the methane sample. The specific heat is

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¹ Figures in brackets indicate the literature references at the end of this paper.

Table 1. Specific heat of saturated liquid methane, C_{σ} or C_{SAT} ; specific heat at constant volume of saturated liquid calculated, C_{V} ; specific heat of the two phase (liquid-vapor) system, C_{2} ; heat capacity of the calorimeter (empty) C_{0} , and heat capacity of the calorimeter (full) $\Delta Q/\Delta T$ or DQ/DT, with temperature, pressure, density, and temperature increment, DT

ID	Temp K	Press bar	Dens mol/l	DT K	DQ/DT J/K	C ₀ J/K	C_2 J/mol · K	$C_V \operatorname{J/mol} \cdot \operatorname{K}$	C_{sat} J/mol · K
201	95.402	0.209	27.755	3.657	133.482	46.671 46.881	54.418	34.274	54.240
401	95.846	.219	27.718	5.799	139.159	46.881	54.252	34.103	54.131
202	99.021	.311	27.450	3.574	135.870	48.348	54.864	34.169	54.647
302	101.651	.409 .422 .448	27.224	6.638 6.420	141.300	49.520	55.058 54.943	34.016	54.877
402	101.961	.422	27.198	6.420	143.111	49.656	54.943	33.883	54.790
203	102.574	.448	27.145	3.524	137.905	49.923	55.152	33.898	54.896
204	106.891	.673	26.767	5.110	140.924	51.750	55.899	33.941	55.602
303	108.219	.758	26.649	6.495 7.236	145.302	52.293 52.528	55.794 55.483	33.710	55.583
403	108.800	.797 1.097	26.597	6.273	146.902	52.528	55.483	33.349	55.315
$\frac{205}{304}$	112.604 115.165	1.097	26.254 26.019	7.386	144.013	54.022	56.410	33.478	56.075
206	119.117	1.802	25.649	6.702	149.404 147.576	54.988 56.412	56.638 57.144	33.391 33.041	56.434 56.810
305	122.474	2.278	25.327	7.194	153.257	57.561	57.144	32.862	57.287
405	123.367	2.270	25.240	7.498	154.829	57.858	57.404 57.008 57.899 57.992	32.389	56.996
207	125.766	2.419 2.830	25.005	6.568	151.006	58.636	57.000	32.534	57.645
406	130.765	3.852	24.500	6.568 7.297	158.819	60.171	57.099	32.000	58.245
208	132.274	4.209	24.343	6.430	154.477	60.612	58.834	32.162	58.774
1001	132.751	4 326	24.293	5.117	122.552	60.750	62.894	32.148	58.879
902	135.455	4.326 5.038	24.007	4.538	137.072	61.512	60.813	31.499	58.930
1002	137.805	5.723	23.752	4.973	125.195	62.151	64.157	31.650	59.729
903	139.970	6.412	23.513	4.476	139.223	62.720	61.570	30.986	59.698
801	144.305	6.412 7.971	23.017	4.476 4.019	141.250	63.808	62.323	30.460	60.560
904	144.401	8.009	23.005	4.386	141.728	63.831	62.689	30.797	60.929
802	148.500	8.009 9.725 9.896	22.514	4.371 4.316	143.789	64.800	63.565	30.407	62.033
905	148.881	9.896	22.467	4.316	143.807	64.888	63.565 63.509	30.230	62.005
1003	150.824	10.807 11.798 11.978	22.224	4.332	133.134	65.326	68.994	31.449	64.014
803	152.809	11.798	21.969	4.247 4.229 4.941	146.566	65.763	65.022 65.129	30.468	63.898
906	153.157	11.978	21.924	4.229	146.775	65.838	65.129	30.459	64.048
1004	155.542	13.267	21.606	4.941	135.238	66.345	70.092	30.518	65.246
804	157.043	14.128	21.401	4.180	148.588	66.657	65.926	29.932	65.435
907	157.355	14.312	21.358	4.167	148.747	66.721 67.080	66.001	29.899	65.569
1005	159.127	15.388 16.707	21.107	4.035	137.307	67.080	71.446	30.244	66.905
805	161.181	16.707	20.808	4.095	151.123	67.486	67.294 67.375	29.823	67.733
908	161.483	16.908 18.036 18.492	20.763	4.088	151.284	67.545	67.375	29.793	67.898
1006	163.136	18.036	20.512	3.982	138.917	67.864	72.280	29.161	68.379
1402	163.782	18.492	20.412	5.441	153.354	67.987	68.702	30.257	69.936
806	165.249	19.556	20.179	4.036	153.713	68.263	68.749	29.746	70.534
1407	165.128	19.467 19.779	20.199	5.131	154.144	68.240	69.132 68.838	30.171	70.865
909	165.548	19.779	20.131	4.043	153.880	68.318	68.838	29.719	70.745
1007 807	166.549	20.536 22.687	19.967	2.738	141.994	68.503	74.756	29.907	71.756
910	169.253 169.565	22.945	19.505 19.450	3.963 3.949	156.273	68.991	70.216	29.609	73.960
1220	170.157	23.440	19.450	7.335	156.656 138.896	69.047 69.151	70.480 79.614	29.743	74.411
1008	170.137	23.440	19.344	4.907	144.726	69.159	76.862	29.404 30.033	74.696 75.369
1408	170.197	23.474 23.520	19.330	4.297 5.020	157.666	69.168	71.213	30.181	75.575
1403	170.231	24.243	19.172	5.271	158.018	69.316	71.213	29.980	76.320
808	173.180	26.094	18.773	3.890	150.010	69.675	71.370	29.577	78.540
808 911	173.480	26.369	18.714	3.890 3.873	159.054 159.572	69.675 69.727	71.898 72.273	29.813	79.194
701	173.505	26.392	18.709	5.002	141.928	69.731	81.284	29.262	78.678
1216	174.032	26.880	18.603	7.180	141.932	69.820	82.310	29.445	79.623
1009	174.429	27.252	18.522	4.167	148.478	69.887	79.930	30.556	81.334
1409	175.228	28.012	18.355	4.900	161.213	70.021	73.374	30.069	82.128
1404	176.295	29.051	18.125	5.118	162.367	70.198	74.158	30.312	84.253
809	177.029	29.782	17.961	3.811	162.720	70.318	74.323	30.097	85.466
1221	177.420	30.177	17.872	6.968	146.364	70.382	86.720	31.201	87.382
702	177.902	30.670	17.760	3.799	145.938	70.461	84.967	29.552	86.790
1010	178.557	31.349	17.603	4.090	151.355	70.567	82.156	29.861	88.641
1200	180.613	33.553	17.078	5.694	148.814	70.895	88.923	30.420	95.067
1217	181.034	34.018	16.963	6.825	149.125	70.961	89.202	30.254	96.349
703	181.645	34.702	16.790	3.688	150.564	71.057	89.496	30.451	98.844
1011	182.572	35.759	16.516	3.940	156.745	71.201	86.983	31.025	103.442
1222	184.222	37.703	15.976	6.616	154.219	71.454	94.445	31.451	113.330
704	185.271	38.982	15.588	3.549	156.464	71.613	95.503	31.421	121.769
1201	186.127	40.050	15.236	5.329	158.456	71.742	98.948	32.509	132.153
	107 577	41.915	14.530	6.026	151.278	71.957	80.630	16.306	141.359
1012 1218	187.577 187.633	41.988	14.499	6.358	160.079	71.965	00.000	10.500	141.007

obtained by dividing the heat capacity by the amount of methane, N.

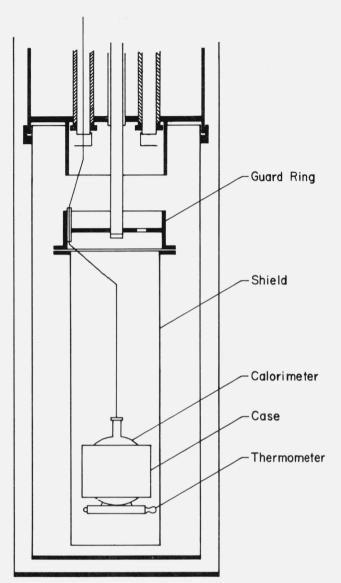


Figure 1. Calorimeter and cryostat.

Actually, several corrections are made to the above. Since the sample holder is a thin stainless steel sphere (~ 0.16 mm wall thickness and 5 cm diam), it stretches as the pressure increases. This allows work to be done by the methane due to the increase of the sample volume. This correction [4, 5, 6], developed by Walker [9], ranges from 0.5 to 5 percent of the resulting C_V value. However, it can be made accurately.

Of the three variables, pressure, temperature, and density, only temperature is measured during the measurement of an isochore. The pressure and temperature are measured at filling and the density calculated from the PVT surface [10]. The amount of methane, N, is calculated from the volume V(T, P) as previously determined [3, 5]. The density for each G_V measurement is calculated from the filling density

after correcting for sample holder expansion and the amount compressed into the filling capillary [6].

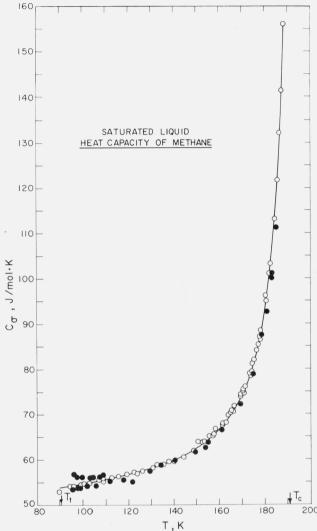


Figure 2. Specific heat of the saturated liquid for methane, this work, ○, the measurements of Wiebe and Breevort ● [12].

In the case of the C_{σ} measurement, the two phase heat capacity (liquid and gas) is first determined as the difference of the total heat capacity (DQ/DT, column 6 of table 1) and the empty heat capacity (Co, column 7) and the result divided by the total amount of sample (C₂, column 8). Then the effects of the latent heat of vaporization and heat absorbed by the vapor are subtracted [3, 5, 7] to give C_{σ} (column 10). This type of correction is derived by Hoge [11].

The temperature increment, resulting from a constant power input over a time Δt , is evaluated at the middle of the heating interval by extrapolating the temperature drift rates evaluated just before heating and after an equilibrating time has elapsed (about 20 min). Care was taken to reduce the effects of noise on drift rate by taking many (10 to 20) measurements of time and temperature.

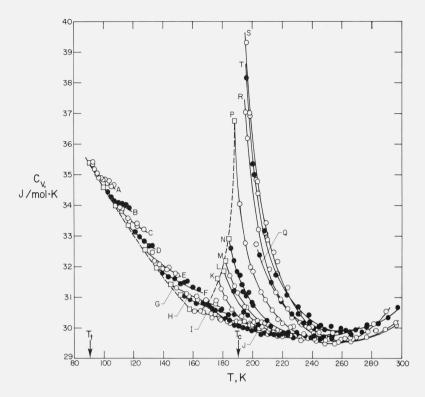


FIGURE 3. Specific heat at constant volume of methane on isochores versus temperature.

Open and closed circles on alternate isochores are for clarity.

A - 28.0 mol/l,	B-27.4 mol/l	C-26.7 mol/l
D - 25.8	E - 24.7	F - 24.0
G - 23.0	H - 22.1	I - 21.3
J-19.5	K - 18.0	L - 17.0
M - 16.7	N - 16.0	P - 14.4
Q - 13.1	R – 13.1	S - 11.8
T - 7.9		

4. Results

The specific heat of the saturated liquid was measured for 66 temperatures. The lowest was 95 K (triple point, 90.68 K) and the highest 187 K (see fig. 2 and table 1). The estimated uncertainty in the measured value of C_{σ} is about 0.5 percent generally but increasing to about 5 percent within a few Kelvin of the critical point. The data of Weibe and Breevort [12] are shown for comparison as the closed circles. Their measurements agree remarkably well with the new data, considering the state of the art at that time.

Figure 3 and table 2 show C_V as a function of temperature for the various isochores. The dashed line is the locus of C_V for saturated liquid as extrapolated from the C_V measurements. The uncertainties in C_V are the same as for C_σ . Densities Q, R, S, and T have uncertainties as large as 5 percent near critical temperature, indicated as T_c on figure 3. Density T is 22 percent less than critical density.

are computed from C_{σ} data by adding the term $T\left(\frac{\partial P}{\partial T}\right)_v$ $\frac{dV}{dT}$. These derivatives, evaluated analytically from a representation of the PVT surface [2], introduce the scatter and the lowering of the values from the extrapolated values which have essentially the same accuracy

Figure 4 shows C_V at saturation. The circles are values extrapolated from the C_V data and the triangles

Comparison was made with the C_p data of Jones et al. [17] on their 2000 lb/in² (136.7 bar) by interpolation of the C_V data and adding the PVT contribution. Figure 5 shows the close agreement of the two sets of data. The other curve is calculated from spectroscopic heat capacities together with the PVT term above critical temperature, (T_c) . Below the critical temperature, latent heats must also be used. The discontinuity is, of course, at T_c .

as the measured C_V values.

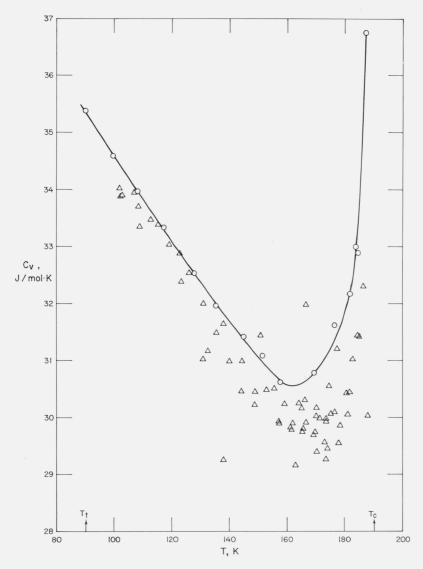


FIGURE 4. C_v of liquid methane evaluated at the liquid-gas boundary. Extrapolation of $C_r(\bigcirc)$, calculation from C_σ using PVT surface (\triangle) .

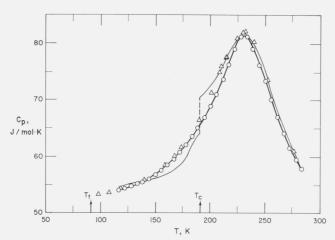


Figure 5. Comparison of methane C_p from Jones, et al. (-O-); to C_p calculated from C_v data, this work (\triangle), and to C_p calculated from PVT data (--).

Table 2. Specific heat at constant volume, C_V , of methane; heat correction for calorimeter expansion Cl, heat capacity of empty calorimeter, CO, total heat capacity of calorimeter (full) $\Delta Q/\Delta T$ or DQ/DT, with temperature, pressure, density, and temperature increment, DT

Dec Press Press Den DT DQIDT Co Co Co DT Jimol K Jim	ID	Т	D.				C-	1	
2203 201.339 58.027 7.991 5.459 94.406 73.865 1.167 35.004 2210 200.161 65.521 7.988 7.419 94.162 74.729 1.175 33.153 33.153 2204 200.161 65.521 7.988 7.419 94.162 74.729 1.175 33.1412 2212 222.247 81.508 5.241 7.880 7.419 94.182 74.729 1.175 33.1412 2212 222.947 81.508 7.080 7.361 94.607 76.445 1.182 31.004 2205 222.993 81.658 7.080 7.361 94.607 76.445 1.182 31.004 2205 222.993 81.658 7.080 7.361 94.607 76.445 1.182 31.005 2206 230.373 89.568 7.077 7.387 95.264 77.266 1.189 30.668 2213 220.4533 80.668 7.077 7.387 95.264 77.226 1.189 30.668 2213 220.4533 80.668 7.077 7.344 95.130 77.224 1.189 30.658 2204 224.333 104.881 7.070 7.222 99.233 73.80 96.80 7.072 7.322 95.818 70.90 1.189 30.455 2215 22.545.476 105.669 7.069 7.332 99.233 73.619 2.02 23.00.45 2216 252.815 113.433 7.066 7.332 97.017 79.355 .210 30.067 2218 20.639 127.671 7.959 7.246 97.900 80.436 222 29.785 1505 195.780 15.853 10.176 6.728 10.104 10.104 73.346 1.189 30.607 1521 198.426 557.304 10.175 5.257 10.104 77.343 1.189 30.59 1521 198.426 557.804 10.174 5.244 101.071 73.480 1.189 36.991 1521 198.426 557.804 10.174 5.244 101.071 73.480 1.189 36.991 1522 203.1425 64.857 10.171 6.470 100.990 74.408 1.195 4.403 1.195 4.403 1.155 2.203 33.004 3.203 33.004 33	ID								
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2206 230.473 89.583 7.977 7.387 95.264 77.226 1.89 30.698 2213 230.453 89.668 7.977 7.484 95.130 77.294 1.89 30.455 2207 237.534 97.229 7.973 7.324 95.819 77.940 1.95 2214 234.476 105.600 7.790 7.382 95.348 77.610 30.409 2215 234.476 105.600 7.790 7.292 95.234 786.10 30.000 2216 234.476 105.600 7.790 7.292 95.234 786.10 30.000 2218 266.349 127.671 7.959 7.246 97.960 80.436 2222 29.785 1505 195.780 53.853 10.176 6.728 102.498 73.123 1.85 39.325 1523 198.095 57.310 10.175 5.257 10.1044 73.496 1.89 36.999 1521 138.426 57.804 10.174 5.284 101.071 73.480 1.89 36.999 1521 139.426 57.804 10.174 5.284 101.071 73.480 1.89 36.999 1522 203.373 65.206 10.171 5.301 10.189 74.128 1.195 34.432 1524 203.375 65.206 10.171 5.301 10.198 74.128 1.195 34.432 1525 208.704 73.193 10.167 5.326 99.81 74.173 1.97 34.832 1525 208.704 73.193 10.167 5.326 99.81 74.173 20.433 34.83 1523 209.057 73.722 10.167 5.326 99.81 74.795 20.33 33.078 1524 203.375 65.206 10.171 5.301 99.81 74.173 20.433 34.81 1524 203.375 65.206 10.171 5.300 99.81 74.173 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.433 20.434 20.433 20.	2205					94.691			
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2214 238.128 97.862 7.973 7.382 95.748 77.998 1.96 30.198 2208 2244 733 104.881 7.970 7.292 96.283 78.619 202 30.045 2215 245.476 105.669 7.969 7.369 96.374 78.667 203 30.084 2216 225.815 113.433 7.966 7.362 99.574 78.667 203 30.084 2218 256.349 127.671 7.959 7.286 97.900 80.436 222 29.785 1522 198.095 57.310 10.175 5.257 101.084 73.436 1189 36.999 1523 198.095 57.310 10.175 5.257 101.084 73.436 1189 36.991 1521 198.426 57.804 10.174 5.284 101.071 73.480 1189 36.991 1521 1502 203.142 64.857 10.171 6.923 100.060 74.028 1.94 34.818 36.291 1502 203.142 64.857 10.171 6.923 100.060 74.028 1.94 34.818 1502 203.137 65.206 10.171 5.301 10.0142 74.128 1.96 34.793 1522 308.707 73.323 10.177 5.330 49.881 74.798 203 33.073 34.793 1523 208.707 73.323 10.177 5.330 49.883 74.798 203 33.073 34.793 1523 208.707 73.323 10.177 5.330 49.881 74.798 203 33.073 34.793 1533 209.833 74.915 10.166 6.942 99.491 74.885 2.204 33.279 1503 209.833 74.915 10.166 6.942 99.499 77.5748 203 32.279 1503 209.833 74.915 10.166 6.942 99.499 77.5748 203 32.279 1503 209.833 74.915 10.166 6.945 99.479 75.715 2.13 30.276 1504 216.813 85.365 10.161 6.945 99.479 75.715 2.13 30.776 1504 216.813 85.365 10.161 6.945 99.479 75.715 2.13 30.726 1504 216.813 85.365 10.161 6.945 99.479 75.715 2.13 31.750 1504 216.813 85.365 10.161 6.945 99.479 75.715 2.13 31.750 1504 216.813 85.365 10.167 6.943 99.937 76.489 2.23 31.318 1510 23.7756 116.874 19.184 10.184 10.184 2.699 10.185 20.484 10.184 10.184 2.699 10.185 20.484 31.790 223.396 95.556 10.157 6.923 99.937 76.489 2.23 31.318 1510 23.7756 116.844 10.184 10.184 6.904 10.084 77.796 2.23 99.937 76.489 2.23 31.318 1510 23.7756 11.839 7.265 10.165 6.935 10.167 6.935 99.937 76.489 2.23 30.304 2.299 2.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.004 30.23 30.304 30.304 30.23 30.304					7 324	95.100	77 940	105	
2208 244,733 104,881 7,970 7,292 96,283 78,619 2.02 30,045 2216 225,815 113,433 7,966 7,332 97,017 79,335 2.10 30,067 2218 2266,349 113,433 7,966 7,332 97,017 79,335 2.10 30,067 1505 195,780 58,853 10,176 6,728 102,498 73,123 183 39,325 1523 198,095 57,310 10,175 5,257 101,084 73,432 189 36,999 1521 198,466 57,804 10,174 5,284 101,071 73,480 189 36,999 1506 202,601 64,048 10,171 6,470 106,980 74,098 195 44,032 1524 203,375 65,206 10,171 5,301 99,831 74,173 197 34,382 222 203,731 65,206 10,171 5,324 99,381 74,173 197					7 382	95.748	77 998	196	
2215 245.476 105.669 7.969 7.369 90.374 78.687 203 30.084 2218 266.349 127.671 7.969 7.336 99.374 78.687 203 30.087 2218 266.349 127.671 7.959 7.246 97.960 80.436 222 29.785 1505 195.780 53.853 10.176 6.728 102.498 73.123 1.85 39.325 1522 198.095 57.310 10.175 5.257 101.084 73.406 1.189 36.999 1523 198.095 57.304 10.177 6.823 101.084 73.408 1.189 36.999 1524 203.3375 6.206 10.171 6.470 10.6980 74.098 1.195 4.403 1524 203.375 65.206 10.171 5.300 100.142 74.128 1.196 34.793 1522 203.731 65.206 10.171 5.320 19.881 74.173 1.197 34.882 1525 208.704 73.193 10.167 5.326 99.856 74.838 2.204 33.447 1507 209.526 74.426 10.166 6.942 99.491 74.895 203 33.447 1507 209.526 74.426 10.166 6.942 99.491 74.895 203 33.2879 1526 214.044 81.206 10.166 6.955 99.636 75.493 2.204 33.402 1528 203.833 83.365 10.161 6.956 99.376 75.434 2.11 32.476 1508 216.467 84.845 10.161 6.956 99.479 75.755 2.24 33.020 1526 214.044 81.206 10.164 5.346 99.376 75.434 2.11 32.476 1508 212.399 853 83.856 10.161 6.956 99.479 75.715 2.13 31.750 1508 21.4043 81.206 10.164 5.346 99.376 75.434 2.11 32.476 1509 223.399 853 83 83.655 10.161 6.956 99.479 75.715 2.13 31.750 1508 21.4048 81.306 81.0161 6.956 99.479 75.715 2.23 33.020 1526 244.636 127.181 10.142 6.964 10.104 7 1509 223.399 853 83 83.65 10.161 6.956 99.479 75.715 2.24 32.185 1510 223.756 11.844 10.147 6.901 10.044 37 77.962 2.24 2.30 33.18 1511 223.756 11.844 10.147 6.901 10.044 37 77.962 2.24 2.33 33.18 1512 23.756 11.844 10.147 6.901 10.044 37 77.962 2.24 2.29 9.955 1513 25.468 13.7466 10.137 6.819 10.147 7.902 2.24 2.29 2.29 2.20 2.20 2.20 2.20 2.20 2.20					7 292	96 283	78 619	202	
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2218 266.349 127.671 7.959 7.246 97.960 80.436 222 29.785								210	
1523 198,095 57,310 10,175 5,257 101,084 73,436 189 36,999 1502 202,001 64,048 10,171 6,923 100,060 74,028 194 34,818 1502 203,142 64,857 10,171 6,470 106,990 74,098 195 44,032 1524 203,375 65,206 10,171 5,301 100,142 74,128 196 34,793 1522 208,704 73,193 10,167 5,334 99,538 74,175 203 33,078 1523 209,057 73,722 10,167 5,334 99,538 74,795 203 33,078 1523 209,057 73,722 10,167 5,334 99,538 74,495 203 32,879 1525 208,704 73,193 10,166 6,942 99,491 74,895 203 32,879 1526 214,044 81,206 10,166 6,945 99,497 74,895 203 32,879 1526 214,044 81,206 10,164 5,346 99,436 74,935 204 33,175 1504 216,813 85,365 10,161 6,936 99,479 75,715 211 32,476 1504 216,813 85,365 10,161 6,945 99,497 75,755 214 32,185 1510 230,790 16,373 10,151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 29,998 1512 244,636 127,186 10,142 6,804 100,993 76,489 223 33,30,432 1513 235,488 137,461 10,142 6,804 100,493 77,268 233 30,432 235,488 139,493 10,136 6,725 102,104 80,491 226,550 226,550 226,560 20,494 10,167 6,901 20,404		266.349	127.671					.222	
1523 198,095 57,310 10,175 5,257 101,084 73,436 189 36,999 1502 202,001 64,048 10,171 6,923 100,060 74,028 194 34,818 1502 203,142 64,857 10,171 6,470 106,990 74,098 195 44,032 1524 203,375 65,206 10,171 5,301 100,142 74,128 196 34,793 1522 208,704 73,193 10,167 5,334 99,538 74,175 203 33,078 1523 209,057 73,722 10,167 5,334 99,538 74,795 203 33,078 1523 209,057 73,722 10,167 5,334 99,538 74,495 203 32,879 1525 208,704 73,193 10,166 6,942 99,491 74,895 203 32,879 1526 214,044 81,206 10,166 6,945 99,497 74,895 203 32,879 1526 214,044 81,206 10,164 5,346 99,436 74,935 204 33,175 1504 216,813 85,365 10,161 6,936 99,479 75,715 211 32,476 1504 216,813 85,365 10,161 6,945 99,497 75,755 214 32,185 1510 230,790 16,373 10,151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 29,998 1512 244,636 127,186 10,142 6,804 100,993 76,489 223 33,30,432 1513 235,488 137,461 10,142 6,804 100,493 77,268 233 30,432 235,488 139,493 10,136 6,725 102,104 80,491 226,550 226,550 226,560 20,494 10,167 6,901 20,404	1505	195.780	53.853	10.176	6.728	102.498	73.123	.185	39.325
1521 198,426 57,804 10,174 5,294 101,071 73,480 189 36,921 1506 202,601 64,048 10,171 6,470 106,980 74,098 195 44,032 1522 203,373 65,278 10,171 5,301 100,142 74,128 196 34,793 1522 203,731 65,739 10,171 5,301 99,881 74,173 197 34,382 1525 208,704 73,193 10,167 5,334 99,538 74,173 197 34,382 1525 208,704 73,193 10,167 5,336 99,887 74,173 197 34,382 1523 209,957 73,722 10,167 5,336 99,856 74,838 204 33,447 1503 209,835 74,426 10,166 6,942 99,491 74,895 203 33,287 1503 209,835 74,916 10,166 6,945 99,473 75,435 204 33,200 1536 216,681 36,365 10,161 6,945 99,373 75,434 211 32,476 33,020 1509 223,396 50,525 10,157 6,923 99,937 76,449 13,178 1510 220,790 106,373 10,151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 233 30,432 1512 244,636 127,181 10,142 6,864 100,993 77,64,99 233 30,432 1513 251,488 37,466 10,137 6,819 10,467 79,221 29,956 1514 259,403 149,331 10,131 6,782 102,164 80,421 290,532 1514 259,403 149,331 10,131 6,782 102,164 80,421 290,532 1514 259,403 149,331 10,131 6,782 102,164 80,421 290 29,560 1517 282,516 83,843 10,114 6,617 104,667 81,599 301 29,952 223 20,566 10,105 6,556 105,109 82,444 3,19 30,179 224 205,924 70,601 11,832 7,393 103,134 74,198 226 32,223 30,432 221 21,678 29,586 21,187 30,438 20,438 20,438 20,444 3,19 30,179 20,565 20,566 20,565 11,839 11,800 7,311 10,485 77,599 27,565 30,009 20,443 30,009 20,443 31,483 30,443 30,444 30	1523	198.095	57.310	10.175	5.257		73.436	.189	36,999
1506 202.601 64.048 10.171 6.923 100.060 74.028 1.94 34.818 1502 203.142 203.375 65.206 10.171 5.301 100.142 74.128 1.96 34.793 1522 203.731 65.739 10.171 5.320 99.881 74.173 1.97 34.382 1525 208.704 73.193 10.167 5.326 99.881 74.795 2.03 33.078 1523 209.057 73.722 10.167 5.326 99.886 74.838 2.04 33.447 1507 209.526 74.426 10.166 6.955 99.636 74.838 2.04 33.447 1503 209.853 74.915 10.166 6.955 99.636 74.935 2.04 33.020 1526 214.044 81.206 10.164 5.346 99.736 75.434 211 32.476 1508 216.467 84.845 10.161 6.956 99.479 75.715 213 31.750 1504 216.813 85.365 10.161 6.945 99.842 75.755 214 32.185 1509 223.396 95.256 10.157 6.923 99.377 76.489 223 31.318 1510 230.790 100.373 10.151 6.920 100.066 77.268 2.33 30.432 1511 237.756 116.844 10.147 6.901 100.443 77.962 2.42 29.998 1512 244.636 127.181 10.142 6.864 100.993 78.610 2.51 29.857 1513 259.403 149.331 10.136 6.782 102.116 81.838 2.02 31.318 1516 259.403 149.333 10.136 6.782 102.116 81.838 2.02 31.310 2.29.650 1515 229.166 188.866 10.103 6.782 102.116 81.538 2.02 31.002 2.02.560 1517 229.522 205.551 18.89 7.285 104.603 31.344 74.198 2.26 32.225 2.26	1521	198.426	57.804	10.174	5.284	101.071	73.480	.189	36.921
1502 203,142 64,857 10,171 6,470 106,980 74,098 1.95 44,032 1522 203,731 65,739 10,171 5,301 100,142 74,128 1.96 34,793 1525 208,704 73,193 10,167 5,334 99,538 74,795 203 33,078 1525 209,057 73,722 10,167 5,326 99,856 74,838 204 33,447 1507 209,526 74,426 10,166 6,942 99,491 74,895 203 32,879 1526 214,044 81,206 10,164 5,346 99,736 75,334 204 33,020 1526 214,044 81,206 10,164 5,346 99,736 75,434 211 32,476 1508 216,467 84,845 10,161 6,956 99,479 75,715 213 31,750 1504 216,813 85,365 10,161 6,956 99,479 75,715 213 31,750 1509 223,396 95,256 10,157 6,923 99,937 76,489 223 31,318 1510 230,790 106,373 10,151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 29,998 1512 244,636 127,181 10,142 6,864 100,993 78,610 251 29,857 1513 251,488 137,466 10,137 6,819 101,457 79,221 261 29,650 1517 282,516 188,843 10,113 6,782 102,116 79,886 271 29,662 1515 266,154 159,433 10,131 6,782 102,116 79,886 271 29,662 203,596 10,105 6,625 104,538 20,92 203,596 10,105 6,625 104,538 20,92 203,596 10,105 6,625 104,538 20,92 204 37,165 224 203,924 70,601 1,832 7,393 10,131 7,799 22,663 23,665 20,899 10,105 6,625 104,538 20,92 204,226 33,223 225 211,370 84,550 1,839 7,285 104,709 73,232 206 33,223 227 226,191 12,653 11,818 7,744 10,607 13,839 77,549 226 33,223 227 226,191 12,653 11,818 7,744 10,608 7,797 75,618 250 30,143 229 244,799 248,745 248,7	1506	202.601	64.048	10.171	6.923	100.060	74.028	.194	34.818
1524 203,375 65,206 10.171 5,301 100.142 74,128 1.96 34,793 1525 208,704 73,193 10.171 5,320 99,881 74,795 203 33,078 1523 209,057 73,722 10.167 5,326 99,856 74,838 204 33,447 1507 209,526 74,426 10.166 6,942 99,491 74,895 203 32,879 1503 209,853 74,915 10.166 6,955 99,636 74,935 204 33,020 1526 214,044 81,206 10.164 5,346 99,736 75,434 211 32,476 1508 216,467 38,485 10.161 6,956 99,479 75,715 213 31,750 1504 216,813 85,365 10.161 6,945 99,842 75,755 214 32,185 1510 230,790 106,373 10.151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10.147 6,901 100,443 77,962 242 29,998 1512 244,636 127,181 10.142 6,804 10.093 78,610 251 29,857 1513 254,648 10.137 6,819 10.1457 79,221 261 29,650 1514 259,403 149,331 10.131 6,782 102,116 79,886 271 296,650 1517 282,516 183,843 10.146 6,617 104,067 81,599 301 29,922 203,596 10.105 6,556 105,109 82,444 319 30.170 224 209,964 1519 295,822 203,596 10.105 6,556 105,109 82,444 319 30.170 224 203,924 70,601 11,832 7,333 10,126 6,725 104,067 81,599 301 29,922 204 218,787 226 118,787 98,572 11,819 74,111 10,2950 75,979 256 30,092 206 223,633 107,819 11,815 8,022 103,324 76,517 265 30,092 206 223,653 107,819 11,815 8,022 103,324 76,517 265 30,092 206 223,653 107,819 11,815 8,022 103,324 76,517 265 30,092 206 223,653 107,819 11,815 8,022 103,324 76,517 265 30,092 206 223,653 107,819 11,816 7,334 10,435 7,334 10,435 7,344 10,435 7,549 283 30,130 209 248,734 10,438 10,448 206 218,787 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604 206,604	1502	203.142	64.857	10.171	6.470	106.980	74.098	.195	
1522 203,731 65,739 10.171 5.320 99.881 74.173 1.197 34.382 1525 208,704 73.193 10.167 5.334 99.538 74.795 2.03 33.078 1523 209.057 73.722 10.167 5.326 99.856 74.838 2.04 33.447 1507 209.526 74.426 10.166 6.942 99.491 74.895 2.03 32.879 1526 214.044 81.206 10.164 5.346 99.736 74.935 2.04 33.020 1526 214.044 81.206 10.164 5.346 99.736 75.434 2.11 32.476 1508 216.467 84.845 10.161 6.956 99.479 75.715 2.13 31.750 1504 216.813 85.365 10.161 6.945 99.842 75.755 2.14 32.185 1509 223.396 95.256 10.157 6.923 99.937 76.489 2.23 31.318 1510 230.790 106.373 10.151 6.920 100.066 77.268 2.33 30.432 1511 237.756 116.844 10.147 6.901 100.443 77.962 2.42 29.998 1512 244.636 127.181 10.142 6.804 100.993 78.610 2.51 29.857 1513 251.488 137.466 10.137 6.819 101.457 79.221 2.61 29.650 1514 259.403 149.331 10.131 6.782 102.116 79.886 271 29.652 1515 266.154 159.433 10.126 6.725 102.604 80.421 2.280 29.560 1515 2295.862 203.596 10.110 6.625 104.538 82.032 3.30 29.994 1519 295.822 203.596 10.110 6.625 104.538 82.032 3.30 29.994 1519 295.822 203.596 10.110 6.625 104.538 82.032 3.30 29.994 1519 295.822 203.596 10.110 6.625 104.538 82.032 3.30 29.994 222 222 225 211.370 84.550 11.838 7.285 104.709 73.232 2.09 36.177 2224 239.924 70.601 11.832 7.393 103.134 74.198 2.26 32.255 31.319 11.815 8.022 103.247 75.618 2.26 33.300 29.964 11.2663 11.815 8.022 103.247 75.618 2.26 33.233 223 225 211.370 84.550 11.826 7.394 102.950 75.797 2.26 30.922 225 211.370 84.550 11.815 8.022 103.247 76.89 2.270 30.347 2224 23.993 140.803 11.808 7.394 102.950 75.979 2.266 30.922 204.923 140.803 1		203.375		10.171	5.301		74.128	.196	34.793
1525 208,704 73,193 10,167 5,334 99,538 74,795 203 33,078 1523 209,057 73,722 10,167 5,326 99,856 74,838 204 33,447 1507 209,526 74,426 10,166 6,942 99,491 74,895 203 32,879 1503 209,853 74,915 10,166 6,955 99,636 74,895 204 33,020 1526 214,044 81,206 10,164 5,346 99,736 75,434 211 32,476 1508 216,467 84,845 10,161 6,956 99,479 75,715 213 31,750 1504 216,813 85,365 10,161 6,945 99,842 75,755 214 32,185 1509 223,396 95,256 10,157 6,923 99,937 76,489 223 31,318 1510 230,790 106,373 10,151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 29,998 1512 244,636 127,181 10,142 6,864 100,993 78,610 2.51 29,857 1513 251,488 137,466 10,137 6,819 101,457 79,221 2.61 29,650 1514 259,403 149,331 10,131 6,782 102,116 79,886 2.71 29,632 1515 266,154 159,433 10,126 6,725 102,604 80,421 280 29,560 1517 282,516 183,843 10,114 6,617 104,067 81,599 301 29,992 2560 1517 282,516 183,843 10,114 6,617 104,067 81,599 301 29,992 224 203,596 10,105 6,556 105,109 82,444 3,119 30,170 229 195,627 55,318 11,838 7,285 104,709 73,232 209 3,117 224 203,924 70,601 11,832 7,393 103,134 74,198 226 33,223 225 211,370 84,550 11,826 7,394 102,990 75,618 250 31,148 226 218,787 94,556 30,609 227 226,191 112,653 11,818 7,374 103,274 76,579 256 30,609 227 226,191 112,653 11,819 7,411 103,685 77,559 0,279 30,137 229 244,743 155,761 11,779 75,618 250 30,437 200 248,734 206,534 2	1522					99.881	74.173	.197	34.382
1507 299.526 74.426 10.166 6.942 99.491 74.895 203 32.879 1503 299.853 74.915 10.166 6.955 99.636 74.935 204 33.020 1526 214.044 81.206 10.164 5.346 99.736 75.434 211 32.476 1508 216.467 84.845 10.161 6.956 99.479 75.715 213 31.750 1504 216.813 85.365 10.161 6.945 99.842 75.755 2.14 32.185 1509 223.396 95.256 10.157 6.923 99.937 76.849 2.23 31.318 1510 230.790 106.373 10.151 6.920 100.066 77.268 2.33 30.432 1511 237.755 116.844 10.147 6.901 100.443 77.962 2.42 29.998 1512 244.636 127.181 10.142 6.804 100.993 78.610 2.51 29.857 1513 251.488 137.466 10.137 6.819 101.457 79.221 2.61 29.650 1515 266.154 159.433 10.126 6.725 102.604 80.421 2.280 29.560 1515 229.516 183.843 10.114 6.617 104.067 81.599 301 29.922 1518 289.146 193.696 10.110 6.625 104.538 82.032 3.10 29.964 1519 295.822 203.596 10.105 6.556 105.109 82.444 3.19 30.170 219 195.627 55.318 11.838 9.621 105.430 73.102 2.04 37.165 223 196.581 57.055 11.839 7.285 104.709 73.232 2.09 36.177 224 224.266 22.544 11.822 8.023 10.279 225 211.370 84.550 11.826 7.394 102.930 75.118 242 31.908 225 211.370 84.550 11.826 7.394 102.930 75.118 242 31.908 226 226 218.787 98.572 11.819 7.411 102.950 75.979 256 30.922 226 218.787 98.572 11.819 7.411 102.950 75.979 256 30.922 226 218.787 98.572 11.819 7.941 10.885 78.979 2.70 30.347 227 226.191 112.653 11.813 7.374 103.274 76.789 2.70 30.437 226 228.653 107.819 11.815 8.022 103.247 76.789 2.70 30.437 226 228.653 10.774 11.808 7.947 103.665 77.599 30.92 2.656 30.922 2.656 228.675 10.447 11.748 9.271 108.845 82.476 33.39 2.96.63 2.94.923 140.803 11.800 7.311 10	1525		73.193				74.795	.203	
1503 209,853 74,915 10,166 6,955 99,636 74,935 204 33,020 1526 214,044 81,206 10,164 5,346 99,379 75,715 213 31,750 1504 216,813 83,365 10,161 6,956 99,479 75,715 213 31,750 1504 216,813 83,365 10,161 6,945 99,479 75,755 214 32,185 1509 223,396 95,256 10,157 6,923 99,937 76,489 223 31,318 1510 230,790 106,373 10,151 6,920 100,666 77,268 223 33,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 29,998 1512 244,636 127,181 10,142 6,864 100,993 76,8610 251 29,857 1513 251,488 137,466 10,137 6,819 101,457 79,221 261 29,650 1514 259,403 149,331 10,131 6,782 102,116 79,221 261 29,650 1515 266,154 159,433 10,126 6,725 102,604 80,421 280 29,560 1517 282,516 183,843 10,114 6,617 104,067 81,599 301 29,922 1518 289,146 193,696 10,110 6,625 104,538 82,032 310 29,964 1519 295,822 203,596 10,105 6,556 105,109 82,444 319 30,170 219 195,627 221 213,707 84,550 11,839 7,285 104,709 73,232 209 36,177 224 203,924 70,601 11,832 7,393 103,134 74,198 226 33,223 225 211,370 84,550 11,826 7,394 102,930 75,118 242 31,908 205 215,626 22,584 11,822 8,023 102,779 75,618 250 31,148 226 218,787 98,572 11,819 7,411 102,950 75,979 256 30,922 206 223,653 107,819 11,816 7,946 103,224 76,517 265 30,609 227 226,191 112,653 11,819 7,946 104,835 77,359 0,279 30,155 228 233,566 126,729 11,806 7,338 103,244 76,517 265 30,609 227 226,191 112,653 11,819 7,946 104,835 77,359 0,279 30,155 30,609 227 226,191 112,653 11,819 7,946 104,835 77,359 0,279 30,155 30,609 248,734 155,761 11,792 7,882 104,855 79,726 323 29,534 209 248,734 155,761 11,792 7,882 104,855 79,726 323 29,653 20,653	1523	209.057		10.167	5.326		74.838	.204	33.447
1526	1507						74.895	.203	
1508	1503		74.915				74.935	.204	
1504 216.813 85.365 10.161 6.945 99.842 75.755 2.14 32.185 1509 223.307 90 52.56 10.157 6.920 100.066 77.268 2.33 30.432 1511 237.756 116.844 10.147 6.901 100.443 77.962 2.242 29.998 1512 244.636 127.181 10.142 6.864 100.993 78.610 2.51 29.857 1513 251.488 137.466 10.137 6.819 101.457 79.221 2.61 29.650 1514 259.403 149.331 10.131 6.782 102.116 79.886 2.71 29.632 1515 266.154 159.433 10.126 6.725 102.604 80.421 2.80 29.560 1517 282.516 183.843 10.114 6.617 104.067 80.322 310 29.962 1518 289.146 193.696 10.110 6.625 104.538 82.032 310 29.964 1519 295.822 203.596 10.105 6.556 105.109 82.444 3.19 30.170 219 195.627 55.318 11.838 9.621 105.430 73.102 2.04 37.165 224 203.924 70.601 11.832 7.393 103.134 74.198 2.26 33.223 225 211.370 84.550 11.826 7.394 102.930 77.97 75.618 2.50 31.148 226 221.5626 22.584 11.822 8.023 102.779 75.618 2.50 31.148 226 221.8787 85.572 11.819 7.411 102.950 75.979 2.56 30.690 227 226.191 112.653 11.813 7.374 103.274 76.517 2.65 30.609 227 226.191 112.653 11.813 7.374 103.224 76.517 2.65 30.609 228 233.566 126.729 11.806 7.338 103.858 77.359 0.279 30.155 229 204.923 140.803 11.800 7.311 104.171 78.264 2.96 2.96.53 209 224.7453 172.459 11.745 9.438 10.885 77.359 0.279 30.155 210 257.453 172.459 11.748 9.271 108.845 82.476 3.38 30.098 301 204.751 77.746 31.088 7.244 105.556 74.303 2.99 30.868 302 212.016 39.924 31.066 7.338 106.674 77.600 3.31 30.165 303 219.265 313.319 11.810 30.73 7.146 107.321 78.295 3.47 2.99 30.868 304 226.564 206.677 31.065 7.176 106.674 77.600 3.31 30.165 305 234.072	1526						75.434	.211	
1510 223,396 95,256 10,157 6,923 99,937 76,489 223 31,318 1510 230,790 106,373 10,151 6,920 100,066 77,268 233 30,432 1511 237,756 116,844 10,147 6,901 100,443 77,962 242 29,998 1512 244,636 127,181 10,142 6,864 100,993 78,610 251 29,857 1513 251,488 137,466 10,137 6,819 101,457 79,221 261 29,650 1514 259,403 149,331 10,131 6,782 102,116 79,886 271 29,652 1515 266,154 159,433 10,126 6,725 102,604 80,421 280 29,560 1517 282,516 83,843 10,114 6,617 104,067 81,599 301 29,922 1518 289,146 193,696 10,110 6,625 104,538 82,032 310 29,964 1519 295,822 203,596 10,105 6,556 105,109 82,444 319 30,170 219 195,627 55,318 11,838 9,621 105,430 73,302 204 37,165 223 196,581 57,055 11,839 7,285 104,709 73,232 209 36,177 224 203,924 70,601 11,832 7,393 103,134 74,198 226 33,223 225 211,370 84,550 11,826 7,394 102,930 75,118 242 31,908 205 215,626 92,584 11,826 7,394 102,930 75,118 242 31,908 226 218,787 98,572 11,819 7,411 102,950 75,979 256 30,922 226 227 226,191 112,653 11,813 7,374 103,274 76,789 270 30,347 227 226,191 11,263 11,815 8,022 103,224 76,517 265 30,609 227 226,191 11,653 11,810 7,906 104,383 73,141 293 30,043 229 244,734 135,761 11,792 7,882 104,855 78,979 30,92 206,633 209 248,734 15,761 11,762 11,768 11,765 13,810 17,906 104,383 73,141 296,304 206,472 206,524 206,677 106,693 11,775 9,438 106,408 80,482 339 29,632 211,265 10,242 13,073 7,214 105,859 76,033 299 30,868 304 226,524 226,677 31,065 7,179 106,293 76,624 315 30,478 305 234,072 413,881 13,057 7,166 107,321 78,295 347 29,985 300 206,566 240,797 13,065 7,179 106,293 76,633 299 30,868 304						99.479	75.715	.213	
1510						99.842	75.755	.214	
1511 237.756 116.844 10.147 6.901 100.443 77.962 242 29.998 1512 244.636 127.181 10.142 6.864 100.993 78.610 2551 29.857 1513 251.488 137.466 10.137 6.819 101.457 79.221 .261 29.650 1514 259.403 149.331 10.131 6.782 102.116 79.886 .271 29.632 1515 266.154 159.433 10.126 6.725 102.604 80.421 .280 29.560 1517 282.516 183.843 10.114 6.617 104.067 81.599 .301 29.922 1518 289.146 193.696 10.105 6.625 104.538 82.032 .310 29.964 1519 295.822 203.596 10.105 6.556 105.109 82.444 .319 30.170 1519 295.822 203.596 10.105 6.556 105.109 82.444 .319 30.170 129 195.627 55.318 11.838 9.621 105.430 73.102 .204 37.165 223 196.581 57.055 11.839 7.285 104.709 73.232 .209 36.177 224 203.924 70.601 11.832 7.393 103.134 74.198 .226 33.223 225 211.370 84.550 11.826 7.394 102.930 75.118 .242 31.908 205 215.626 92.584 11.822 8.023 102.779 75.618 .250 31.148 226 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.819 7.411 102.950 75.979 .256 30.922 206 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 .270 30.347 228 233.566 126.729 11.806 7.338 103.838 77.539 .270 30.347 229 224.873.566 126.729 11.806 7.338 103.835 77.539 .2270 30.147 229 224.873.566 126.729 11.806 7.338 103.835 77.539 .283 30.130 229 224.873.566 126.729 11.800 7.311 104.171 78.264 .296 .323 .30.130 229 224.873.566 126.729 11.800 7.311 104.171 78.264 .296 .29.653 30.043 229 224.725 234.875 11.819 7.414 105.556 79.726 .323 29.534 210 257.453 228 233.566 126.729 11.806 7.338 103.855 77.599 .309 29.644 226.524 226.647 11.748 9.271 108			95.256				76.489	.223	
1512	1510						77.268	.233	
1513							77.962	.242	
1514 259,403 149,331 10,131 6.782 102,166 79,866 2.71 29,632 1515 266,154 159,433 10,126 6.725 102,604 80,421 280 29,560 1517 282,516 183,843 10,114 6.617 104,667 81,599 .301 29,922 1518 289,146 193,696 10,110 6.625 104,538 82,032 .310 29,964 1519 295,822 203,596 10,105 6.556 105,109 82,444 .319 30,170 219 195,627 55,318 11,838 9,621 105,430 73,102 .204 37,165 223 196,581 57,055 11,839 7,285 104,709 73,232 .209 36,177 224 203,924 70,601 11,832 7,393 103,134 74,198 .226 33,223 225 211,370 84,550 11,882 8,023 102,779 75,618	1512					100.993	78.610	.251	
1515 266.154 159.433 10.126 6.725 102.604 80.421 280 29.560 1517 282.516 183.843 10.114 6.617 104.067 81.599 301 29.922 1518 289.146 193.696 10.110 6.625 104.538 82.032 3.10 29.964 1519 295.822 203.596 10.105 6.556 105.109 82.444 3.19 30.170 219 195.627 55.318 11.838 9.621 105.430 73.102 2.04 37.165 223 196.581 57.055 11.839 7.285 104.709 73.232 2.09 36.177 224 203.924 70.601 11.832 7.393 103.134 74.198 2.26 33.223 225 211.370 84.550 11.826 7.394 102.930 75.118 2.42 31.908 226 218.787 98.572 11.819 7.411 102.950 75.979 2.56 30.922 206 223.653 107.819 11.815 8.022 103.224 76.517 2.65 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 2.70 30.347 207 231.675 123.117 11.808 7.947 103.685 77.359 0.279 30.155 228 233.566 126.729 11.806 7.338 103.858 77.549 2.83 30.130 229 204.923 140.803 11.800 7.311 104.171 78.264 2.96 29.653 209 248.734 155.761 11.775 9.438 106.408 80.482 33.9 29.632 211 266.957 190.643 11.775 9.438 106.408 80.482 3.39 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 3.355 29.702 214 296.364 246.647 11.748 9.271 108.845 80.440 3.39 29.632 31.485 30.303 219.265 110.242 13.073 7.214 105.556 74.303 2.64 32.393 30.688 30.422 22.016 23.4072 143.881 30.057 7.146 107.321 78.295 78.999 30.662 30.688 30.422 244.345 106.556 241.245 106.556 241.245 106.556 241.245 106.556 241.3481 3.057 7.146 107.321 78.295 78.999 30.686 30.422 244.545 106.556 105.560 71.179 106.293 76.824 3.15 30.686 30.992 29.6256 29.965 30.992 204.8387 176.580 13.056 71.179 106.293 76.824 3.15 30.478 30.992 30.686 30.902 244.3387 176.580 13.006 71.146 107.321 78.295 78.948							79.221	.261	
1517 282.516 183.843 10.114 6.617 104.667 81.599 .301 29.922 1518 289.146 193.696 10.110 6.625 104.538 82.032 .310 29.964 1519 295.822 203.596 10.105 6.556 105.109 82.444 .319 30.170 219 195.627 55.318 11.838 9.621 105.430 73.102 .204 37.165 223 196.581 57.055 11.839 7.285 104.709 73.232 .209 36.177 224 203.924 70.601 11.836 7.394 102.930 75.118 .242 31.908 205 215.626 92.584 11.822 8.023 102.779 75.618 .250 31.148 206 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 .	1514							.271	
1518	1515					102.604	80.421	.280	29.560
1519							81.599	.301	
219 195.627 55.318 11.838 9.621 105.430 73.102 204 37.165 223 196.581 57.055 11.839 7.285 104.709 73.232 209 36.177 224 203.924 70.601 11.826 7.393 103.134 74.198 226 33.223 205 215.626 92.584 11.822 8.023 102.779 75.618 250 31.148 226 218.787 98.572 11.819 7.411 102.950 75.979 256 30.922 206 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 .270 30.347 207 231.675 123.117 11.806 7.338 103.858 77.359 0.279 30.155 228 233.566 126.729 11.806 7.338 103.858 77.549 .283							82.032	.310	
223 196,581 57,055 11,839 7,285 104,709 73,232 209 36,177 224 203,924 70,601 11,832 7,393 103,134 74,198 .226 33,223 205 215,626 92,584 11,826 7,394 102,930 75,118 .242 31,908 206 223,653 107,819 11,815 8,022 103,224 76,517 .256 30,609 227 226,191 112,653 11,813 7,374 103,274 76,789 .270 30,347 207 231,675 123,117 11,806 7,338 103,858 77,359 0,279 30,155 228 233,566 126,729 11,806 7,338 103,858 77,549 ,283 30,130 208 239,625 138,319 11,801 7,906 104,383 78,141 ,293 296 29,653 209 248,734 155,761 11,784 9,556 104,385 78,979	1519	295.822	203.596	10.105	0.550	105.109	82.444	.319	30.170
224 203,924 70,601 11,832 7,393 103,134 74,198 .226 33,223 225 211,370 84,550 11,826 7,394 102,930 75,118 .242 31,908 205 215,626 92,584 11,822 8,023 102,779 75,618 .250 31,148 226 218,787 98,572 11,819 7,411 102,950 75,979 .256 30,922 206 223,653 107,819 11,815 8,022 103,224 76,517 .265 30,609 227 226,191 112,653 11,813 7,374 103,274 76,789 .270 30,347 207 231,675 123,117 11,808 7,947 103,685 77,359 0,279 30,155 228 233,566 126,729 11,806 7,338 103,858 77,549 ,283 30,130 208 239,625 138,319 11,801 7,906 104,383 78,141 ,29					9.621		73.102		
225 211.370 84.550 11.826 7.394 102.930 75.118 .242 31.908 205 215.626 92.584 11.822 8.023 102.779 75.618 .250 31.148 226 218.787 98.572 11.819 7.411 102.950 75.979 .256 30.922 206 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 .270 30.347 207 231.675 123.117 11.806 7.338 103.858 77.549 .283 30.150 228 233.566 126.729 11.806 7.338 103.858 77.549 .283 30.130 208 239.625 138.319 11.801 7.906 104.383 78.141 .293 30.043 229 204.923 140.803 11.800 7.311 104.171 78.264 .29				11.839	7.285		73.232	.209	
205 215.626 92.584 11.822 8.023 102.779 75.618 .250 31.148 226 218.787 98.572 11.819 7.411 102.950 75.979 .256 30.922 206 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 .270 30.347 207 231.675 123.117 11.808 7.947 103.685 77.359 0.279 30.155 228 233.566 126.729 11.806 7.338 103.858 77.549 .283 30.130 208 239.625 138.319 11.801 7.906 104.383 78.141 .293 30.043 229 204.923 140.803 11.800 7.311 104.171 78.264 .296 29.653 209 248.734 155.761 11.792 7.882 104.855 78.979 .		203.924					74.198	.226	
226 218,787 98,572 11,819 7,411 102,950 75,979 .256 30,922 206 223,653 107,819 11,815 8.022 103,224 76,517 .265 30,609 227 226,191 112,653 11,813 7,374 103,274 76,789 .270 30,347 207 231,675 123,117 11,806 7,338 103,858 77,549 .283 30,130 208 233,566 126,729 11,801 7,906 104,383 78,141 .293 30,043 208 239,625 138,319 11,801 7,906 104,383 78,141 .293 30,043 229 204,923 140,803 11,800 7,311 104,171 78,264 .296 29,653 209 248,734 155,761 11,792 7,882 104,855 78,979 .309 29,604 210 257,453 172,459 11,784 9,556 105,552 79,726 .	225	211.370			7.394	102.930		.242	
206 223.653 107.819 11.815 8.022 103.224 76.517 .265 30.609 227 226.191 112.653 11.813 7.374 103.274 76.789 .270 30.347 207 231.675 123.117 11.808 7.947 103.685 77.359 0.279 30.155 228 233.566 126.729 11.806 7.381 103.858 77.549 .283 30.130 208 239.625 138.319 11.801 7.906 104.383 78.141 .293 30.043 229 204.923 140.803 11.800 7.311 104.171 78.264 .296 29.653 209 248.734 155.761 11.792 7.882 104.855 78.979 .309 29.604 210 257.453 172.459 11.784 9.556 105.552 79.726 .323 29.534 211 266.957 190.643 11.775 9.438 106.408 80.482 <td< td=""><td></td><td></td><td></td><td>11.822</td><td>8.023</td><td>102.779</td><td>75.618</td><td>.250</td><td>31.148</td></td<>				11.822	8.023	102.779	75.618	.250	31.148
227 226.191 112.653 11.813 7.374 103.274 76.789 .270 30.347 207 231.675 123.117 11.808 7.947 103.685 77.359 0.279 30.155 228 233.566 126.729 11.806 7.338 103.858 77.549 .283 30.130 208 239.625 138.319 11.801 7.906 104.383 78.141 .293 30.043 229 204.923 140.803 11.800 7.311 104.171 78.264 .296 29.653 209 248.734 155.761 11.792 7.882 104.855 78.979 .309 29.604 210 257.453 172.459 11.784 9.556 105.552 79.726 .323 29.534 211 266.957 190.643 11.775 9.438 106.408 80.482 .339 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td>75.979</td><td></td><td></td></td<>							75.979		
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228 233.566 126.729 11.806 7.338 103.858 77.549 .283 30.130 208 239.625 138.319 11.801 7.906 104.383 78.141 .293 30.043 229 204.923 140.803 11.800 7.311 104.171 78.264 .296 29.653 209 248.734 155.761 11.792 7.882 104.855 78.979 .309 29.604 210 257.453 172.459 11.784 9.556 105.552 79.726 .323 29.534 211 266.957 190.643 11.775 9.438 106.408 80.482 .339 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 .355 29.702 214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .		~		T .	t	t ·	1	1	
208 239.625 138.319 11.801 7.906 104.383 78.141 .293 30.043 229 204.923 140.803 11.800 7.311 104.171 78.264 .296 29.653 209 248.734 155.761 11.792 7.882 104.855 78.979 .309 29.604 210 257.453 172.459 11.784 9.556 105.552 79.726 .323 29.534 211 266.957 190.643 11.775 9.438 106.408 80.482 .339 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 .355 29.702 214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .264 32.393 302 212.016 93.924 13.080 7.229 105.596 75.195 .2									
229 204.923 140.803 11.800 7.311 104.171 78.264 .296 29.653 209 248.734 155.761 11.792 7.882 104.855 78.979 .309 29.604 210 257.453 172.459 11.784 9.556 105.552 79.726 .323 29.534 211 266.957 190.643 11.775 9.438 106.408 80.482 .339 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 .355 29.702 214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .264 32.393 302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .2				11.806	7.338				
209 248.734 155.761 11.792 7.882 104.855 78.979 .309 29.604 210 257.453 172.459 11.784 9.556 105.552 79.726 .323 29.534 211 266.957 190.643 11.775 9.438 106.408 80.482 .339 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 .355 29.702 214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .264 32.393 302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .3				11.801	7.900			.293	
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211 266.957 190.643 11.775 9.438 106.408 80.482 .339 29.632 212 276.534 208.934 11.766 9.341 107.186 81.187 .355 29.702 214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .264 32.393 302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 307 248.387 176.580 13.042 7.078 107.969 78.948 .3									
212 276.534 208.934 11.766 9.341 107.186 81.187 .355 29.702 214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .264 32.393 302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .3									
214 296.364 246.647 11.748 9.271 108.845 82.476 .388 30.098 301 204.751 77.746 13.088 7.244 105.556 74.303 .264 32.393 302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .3								.339	
302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309				11.748					
302 212.016 93.924 13.080 7.229 105.596 75.195 .282 31.485 303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309	301	204. 751	77 746	13 088	7 244	105 556	74.303	264	39 303
303 219.265 110.242 13.073 7.214 105.859 76.033 .299 30.868 304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309									
304 226.524 126.697 13.065 7.179 106.293 76.824 .315 30.478 305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309				13.073					
305 234.072 143.881 13.057 7.166 106.784 77.600 .331 30.165 306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309				13.065					
306 241.245 160.256 13.050 7.146 107.321 78.295 .347 29.985 307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309									
307 248.387 176.580 13.042 7.078 107.969 78.948 .362 29.965 309 262.566 208.987 13.026 7.007 109.144 80.140 .391 29.918 310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309									
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$							78.948		
310 276.780 241.398 13.011 6.874 110.608 81.204 .419 30.309				13.026					

Table 2. Specific heat at constant volume, C_V , of methane; heat correction for calorimeter expansion Cl, heat capacity of empty calorimeter, CO, total heat capacity of calorimeter (full) $\Delta Q/\Delta T$ or DQ/DT, with temperature, pressure, density, and temperature increment, DT-C ontinued

ID	Temp K	Press bar	Den mol/l	DT K	DQ/DT J/K	Co J/K	C1 J/mol·K	C_V J/mol·K
214	002 702	057.210	12.002	6.854	110.947	81.684	.433	20 147
314	283.783	257.318	13.003					30.147
311	290.591	272.756	12.995	6.847	111.617	82.124	.446	30.375
312	297.427	288.216	12.987	6.788	112.344	82.540	.460	30.687
501	191.539	52.228	14.388	7.056	108.595	72.531	.268	34.042
528	195.039	61.226	14.383	8.352	107.756	73.021	.281	32.765
502	198.638	70.602	14.379	7.127	107.453	73.509	.295	32.000
520	200.323	75.028	14.377	8.432	107.534	73.732	.299	31.860
503	205.816	89.577	14.371	7.131	107.532	74.437	.315	31.171
521	208.733	97.366	14.366	8.358	107.655	74.799	.321	30.940
504	212.954	108.696	14.362	7.102	107.804	75.306	.334	30.585
				8.319			.347	30.292
522	217.103	119.884	14.356		107.990	75.788		
505	220.066	127.901	14.353	7.075	108.187	76.123	.356	30.152
523	225.394	142.360	14.346	8.245	108.656	76.704	.369	30.032
506	227.167	147.180	14.344	7.039	108.887	76.892	.375	30.067
524	234.287	166.574	14.334	8.234	109.380	77.621	.392	29.826
507	234.417	166.928	14.335	6.969	109.372	77.634	.393	29.805
508	241.372	185.902	14.326	6.927	109.898	78.307	.411	29.647
525	242.493	188.962	14.324	8.159	109.939	78.412	.412	29.585
509	248.293	204.791	14.317	6.910	110.378	78.940	.428	29.485
		223.622	14.308	6.870	111.009	79.538	.445	29.500
510	255.197		14.500					
511	262.143	242.543	14.299	6.820	111.759	80.107	.461	29.656
514	265.537	251.779	14.294	7.970	112.059	80.373	.468	29.681
512	269.538	262.650	14.289	7.971	112.383	80.678	.478	29.689
515	273.495	273.386	14.284	7.928	112.890	80.969	.487	29.885
513	277.494	284.223	14.278	7.914	113.176	81.255	.497	29.877
516	281.439	294.892	14.273	7.875	113.651	81.527	.506	30.061
517	289.349	316.229	14.262	7.793	114.710	82.045	.524	30.557
011	207.017	010.22	11.202	11170	1111110	02.010	.021	00.001
701	107.047	51,000	16 104	7.170	110 110	70.010	0.050	02.000
701	187.947	51.088	16.104	7.172	110.110	72.012	0.350	32.038
707	188.669	53.498	16.103	6.957	110.164	72.118	.353	31.990
721	191.577	63.245	16.098	6.895	110.072	72.537	.367	31.543
702	195.118	75.188	16.093	7.178	110.019	73.032	.378	31.066
708	195.637	76.943	16.092	6.947	110.062	73.103	.380	31.040
720	199.140	88.833	16.087	6.859	110.111	73.576	.390	30.670
703	202.277	99.525	16.082	7.135	110.530	73.987	.397	30.670
709	202.632	100.738	16.082	6.943	110.308	74.032	.399	30.441
704	209.408	123.943	16.071	7.112	110.909	74.881	.426	30.204
710	209.569	124.495	16.071	6.933	110.994	74.901	.427	30.258
711	216.494	148.306	16.060	6.873	111.429	75.718	.450	29.911
705	216.509	148.360	16.060	7.078	111.388	75.720	.450	29.875
712	223.352	171.937	16.049	6.816	112.095	76.484	.472	29.805
706	223.900	173.825	16.048	7.007	112.128	76.544	.473	29.780
713	230.437	196.359	16.038	6.824	112.126	77.232	.473	29.639
		219.833				77.913	.515	
714	237.251		16.027	6.791	113.485	77.913		29.729
715	244.048	243.213	16.016	6.758	113.994	78.556	.536	29.594
716	250.777	266.302	16.005	6.660	114.660	79.159	.557	29.627
717	257.424	289.044	15.994	6.627	115.322	79.724	.577	29.689
718	264.035	311.587	15.983	6.571	116.177	80.256	.597	29.944
719	270.623	333.970	15.972	6.544	116.590	80.759	.616	29.849
1601	185.501	42.477	16.038	2.172	110.226	71.648	.337	32.608
1602	187.587	49.323	16.035	2.006	110.069	71.959	.348	32.198
1603	189.591	55.934	16.032	2.009	109.944	72.252	.358	31.832
1604	191.595	62.582	16.029	2.004	110.119	72.539	.361	31.732
1618	192.871	66.824	16.024	6.135	109.928	72.719	.367	31.410
1605	193.605	69.272	16.026	2.010	109.753	72.822	.377	31.163
1606	195.615	75.989	16.023	2.012	109.895	73.100	.383	31.041
1607	197.622	82.719	16.020	2.003	110.311	73.373	.389	31.157
1608	199.628	89.464	16.017	2.005	110.203	73.640	.396	30.831
1619	200.031	90.821	16.011	8.252	110.253	73.693	.391	30.746
1620	209.230	121.946	15.996	10.164	110.132	74.859	.419	30.246
1600			15.990				.452	29.793
1609	217.884	151.399	15.986	6.097	111.290	75.877		
1611	223.224	169.616	15.977	6.069	111.946	76.470	.469	29.830
1610	223.903	171.930	15.976	6.052	112.026	76.544	.471	29.834
1622	229.421	190.764	15.964	10.032	112.633	77.128	.484	29.842
1612	229.453	190.871	15.967	6.063	112.588	77.131	.488	29.795
1623	239.424	224.878	15.948	9.937	113.475	78.122	.515	29.681
1613	241.503	231.959	15.948	5.956	113.763	78.319	.525	29.748
1614	247.521	252.433	15.939	5.898	114.298	78.871	.544	29.715
		i						

Table 2. Specific heat at constant volume, C_V , of methane; heat correction for calorimeter expansion Cl, heat capacity of empty calorimeter, CO, total heat capacity of calorimeter (full) $\Delta Q/\Delta T$ or DQ/DT, with temperature, pressure, density, and temperature increment, DT-Continued

Continu	Continuea								
ID	Temp K	Press bar	Den mol/l	DT K	DQ/DT J/K	Co J/K	C1 J/mol·K	C_V J/mol · K	
1615	253.443	272.535	15.929	5.912	114.868	79.389	.562	29.742	
1616	259.333	292.473	15.919	5.842	115.529	79.880	.579	29.869	
1617	265.198	312.270	15.910	5.849	116.001	80.347	.597	29.856	
1000	104.764	45 440	16.700	5.054	110.741	71.507	0.001	01.701	
1309	184.764	45.449	16.723	5.354	110.741	71.537	0.381	31.721	
1301	187.826	56.698 65.099	16.717	6.932	110.769	71.994	.394	31.357	
$\frac{1310}{1302}$	190.103 194.733	82.255	16.714 16.706	5.347 6.892	110.862	72.326	.406	31.150	
1311	194.755	84.904	16.706	5.344	110.968 111.063	72.979 73.077	.423	30.685 30.679	
1303	201.094	105.956	16.696	5.855	111.003	73.833	.427	30.196	
1323	202.937	112.841	16.693	6.031	111.551	74.072	.453	30.190	
1312	206.062	124.532	16.688	5.287	111.919	74.468	.465	30.204	
1304	206.122	124.756	16.689	4.249	111.707	74.475	.466	30.023	
1324	208.680	134.336	16.683	5.477	112.228	74.792	.473	30.184	
1305	210.401	140.788	16.681	4.330	112.079	75.001	.481	29.882	
1313	211.348	144.339	16.679	5.286	112.322	75.115	.483	29.987	
1325	214.143	154.818	16.674	5.464	112.494	75.446	.492	29.847	
1306	215.024	158.123	16.673	4.934	112.592	75.549	.496	29.840	
1314	216.658	164.252	16.670	5.219	112.889	75.737	.501	29.924	
1326	219.582	175.218	16.665	5.433	112.992	76.069	.511	29.727	
1327	225.003	195.545	16.655	5.423	113.635	76.662	.530	29.749	
1317	232.337	223.009	16.643	5.178	114.228	77.426	.555	29.585	
1318	237.657	242.891	16.633	5.448	114.856	77.952	.572	29.651	
1319	243.097	263.174	16.624	5.401	115.579	78.468	.590	29.802	
1320	248.519	283.339	16.614	5.387	115.951	78.960	.608	29.686	
1321	253.921	303.370	16.604	5.359	116.619	79.430	.626	29.831	
1322	259.304	323.264	16.595	5.339	117.189	79.878	.644	29.913	
411	187.325	58.469	17.007	8.019	111.229	71.920	.416	31.221	
401	193.924	83.993	16.997	6.900	111.328	72.867	.443	30.513	
406	196.587	94.337	16.992	7.437	111.563	73.233	.452	30.313	
413	203.953	123.025	16.978	7.970	112.216	74.202	.478	30.119	
414	211.988	154.390	16.964	7.898	113.134	75.192	.507	30.033	
415	219.901	185.282	16.950	7.850	113.769	76.104	.535	29.782	
416	227.768	215.952	16.936	7.807	114.550	76.955	.562	29.698	
417	235.598	246.397	16.922	7.735	115.435	77.751	.590	29.743	
418	245.293	283.931	16.904	7.650	116.261	78.670	.623	29.635	
419	252.926	313.338	16.890	7.598	117.007	79.345	.649	29.667	
1001	170 501	27.079	10.006	2.000	110 404	70.571	460	01 000	
$\frac{1801}{1802}$	178.581 181.649	37.972	18.086 18.080	3.069	112.484	70.571	.469	31.280	
1802	186.224	51.836 72.545	18.068	3.085 6.089	112.625 112.813	71.057 71.756	.496	30.991	
1804	192.299	100.083	18.056	6.060	113.438	72.639	.503 .530	30.598 30.377	
1805	198.354	127.540	18.044	6.039	113.430	73.471	.554	30.090	
1806	204.379	154.828	18.032	6.010	114.564	74.256	.578	29.958	
1807	210.370	181.915	18.019	5.964	115.132	74.998	.602	29.803	
1808	216.641	210.187	18.006	5.923	115.821	75.735	.627	29.741	
1809	222.620	237.053	17.994	5.886	116.615	76.404	.651	29.812	
1810	228.488	263.318	17.982	5.854	117.179	77.031	.674	29.742	
1811	234.304	289.242	17.970	5.825	117.723	77.623	.697	29.683	
1812	240.990	318.901	17.955	5.797	118.614	78.271	.723	29.841	
1709	172.603	40.302	19.500	6.087	114.035	69.577	0.506	20.627	
1710	172.003	73.409	19.300	6.101	114.055	70.566	0.596 .608	30.637 30.586	
1701	181.613	90.419	19.479	6.082	115.092	71.052	.636	30.306	
1711	184.637	107.182	19.472	6.065	115.515	71.517	.650	30.262	
1702	187.628	123.725	19.465	6.054	115.740	71.965	.663	30.094	
1712	190.680	140.564	19.457	6.039	116.187	72.408	.676	30.082	
1703	193.640	156.857	19.450	6.008	116.537	72.827	.690	30.021	
1713	196.693	173.622	19.443	5.997	116.917	73.247	.704	29.980	
1704	199.616	189.630	19.435	5.980	117.239	73.639	.717	29.918	
1714	202.661	206.260	19.428	5.946	117.740	74.036	.731	29.976	
1705	205.568	222.086	19.421	5.941	117.875	74.406	.745	29.798	
1715	208.615	238.633	19.413	5.927	118.353	74.784	.759	29.854	
1706	211.480	254.140	19.406	5.895	118.705	75.131	.772	29.844	
1716	214.522	270.555	19.398	5.886	118.998	75.490	.787	29.783	
1707	217.573	286.970	19.391	5.857	119.326	75.842	.801	29.752	
1717	220.387	302.058	19.384	5.842	119.782	76.158	.814	29.837	
1708	223.411	318.216	19.376	5.818	120.066	76.491	.829	29.789	

Table 2. Specific heat at constant volume, C_v , of methane; heat correction for calorimeter expansion Cl, heat capacity of empty calorimeter, CO, total heat capacity of calorimeter (full) $\Delta Q/\Delta T$ or DQ/DT, with temperature, pressure, density, and temperature increment, DT-Continued

ID	Temp K	Press bar	Den mol/l	DT K	DQ/DT J/K	Co J/K	C1 J/mol·K	C_V J/mol·K
807	161.140	39.441	21.313	5.723	116.134	67.478	.746	30.544
801	165.189	68.515	21.313	6.791	116.134	68.251	.772	30.565
808	166.828	80.226	21.296	5.647	117.232	68.554	.798	30.507
			21.279	6.676	118.171	69.459	.833	30.495
802	171.921	116.429						
809	172.488	120.439	21.279	5.633	118.018	69.557	.831	30.336
810	178.091	159.906	21.262	5.566	118.950	70.491	.859	30.307
803	178.582	163.345	21.258	6.640	118.980	70.571	.859	30.275
811	183.640	198-640	21.244	5.532	119.742	71.365	.890	30.224
804	185.182	209.346	21.238	6.587	119.938	71.600	.896	30.193
812	189.153	236.787	21.227	5.487	120.631	72.188	.921	30.236
805	191.734	254.532	21.218	6.521	120.927	72.559	.933	30.175
813	194.626	274.322	21.210	5.456	121.445	72.964	.953	30.229
806	198.229	298.849	21.197	6.467	121.824	73.454	.971	30.139
814	200.078	311.376	21.193	5.439	122.044	73.700	.985	30.109
2109	153.984	30.846	22.126	4.385	117.420	66.016	.818	31.040
2101	157.876	62.103	22.113	4.327	118.099	66.827	.845	30.931
2102	162.200	96.526	22.098	4.314	118.875	67.684	.927	30.800
2103	166.497	130.432	22.083	4.273	119.755	68.493	.940	30.832
2104	170.767	163.847	22.069	4.251	120.349	69.259	.951	30.716
2105	175.011	196.789	22-054	4.233	120.874	69.985	.976	30.567
2106	179.314	229.914	22.040	4.211	121.698	70.688	1.003	30.615
2107	183.514	261.982	22.025	4.186	122.103	71.346	1.003	30.432
2107	187.701	293.689	22.023	4.164	122.834	71.976	1.029	30.468
		293.009	22.011					
1406	148.828	44.459	22.933	6.789	118.758	64.875	0.899	31.314
1407	155.536	104.131	22.907	6.633	120.057	66.344	1.015	31.098
1402	155.969	107.942	22.906	6.629	120.154	66.435	1.017	31.100
1401	156.936	116.449	22.900	7.882	120.264	66.635	1.020	31.042
1408	162.130	161.805	22.883	6.560	121.193	67.671	1.042	30.958
1403	162.555	165.498	22.881	6.564	121.222	67.753	1.043	30.925
1409	168.648	217.963	22.858	6.496	122.400	68.883	1.075	30.923
1404	169.076	221.618	22.856	6.499	122.320	68.960	1.078	30.826
1410	175.122	272.905	22.834	6.458	123.385	70.003	1.120	30.798
1405	175.530	276.347	22.832	6.440	123.626	70.003	1.123	30.898
2001	139.073	45.399	24.008	4.195	119.866	62.486	0.988	31.796
2002	143.270	88.569	23.990	4.184	120.961	63.554	1.146	31.655
2002	147.448	130.924	23.972	4.155	120.901	64.557		31.612
				4.133			1.165	
2004	151.599	172.491	23.954	4.133	122.597	65.498	1.191	31.437
2005	155.908	215.104	23.935	4.091	123.742	66.422	1.205	31.550
2006	160.011	255.209	23.917	4.084	124.120	67.256	1.236	31.258
2007	164.072	294.445	23.900	4.052	124.977	68.042	1.268	31.267
901	130.508	34.766	24.785	2.255	121.056	60.095	1.097	32.662
909	131.693	48.379	24.772	5.484	121.045	60.443	1.106	32.454
904	132.694	59.842	24.767	5.557	121.433	60.734	1.136	32.479
902	134.136	76.278	24.761	4.991	121.346	61.144	1.174	32.166
910	137.159	110.410	24.746	5.421	122.150	61.977	1.245	32.080
903	139.337	134.756	24.735	5.473	122.514	62.555	1.258	31.949
911	142.547	170.300	24.720	5.356	123.309	63.375	1.283	31.911
906	143.713	183.112	24.715	5.439	123.701	63.663	1.287	31.964
912	147.886	228.554	24.695	5.336	124.401	64.659	1.303	31.785
907	149.124	241.915	24.689	5.389	124.607	64.943	1.313	31.732
913	153.185	285.371	24.670	5.287	125.563	65.844	1.348	31.728
908	154.473	299.029	24.664	5.310	126.059	66.120	1.359	31.839
1201	121.160	64.484	25.872	3.070	122.005	57.118	1.274	33.145
1202	124.223	104.694	25.855	3.048	122.909	58.138	1.400	32.958
1203	127.262	144.001	25.838	3.035	123.532	59.107	1.420	32.757
1204	130.274	182,414	25.822	3.013	124.390	60.025	1.455	32.691
1101	110.867	44.963	26.655	5.194	121.731	53.349	1.309	33.910
1106	111.917	60.514	26.649	5.165	121.991	53.758	1.354	33.789
1103	111.855	59.603	26.649	5.215	121.835	53.734	1.351	33.724
1103	116.030	120.523	26.624	5.136	123.377	55.306	1.503	33.557
			26.618	5.109	123.607		1.510	33.478
1107	117.051	135.181 206.386	26.588	5.057	125.308	55.677 57.432	1.546	33.415
1104	122.089					57.432		
1108	122.094	206.453	26.588	5.051	125.107	57.434	1.546	33.311

Table 2. Specific heat at constant volume, C_V, of methane; heat correction for calorimeter expansion Cl, heat capacity of empty calorimeter, CO, total heat capacity of calorimeter (full) $\Delta Q/\Delta T$ or DQ/DT, with temperature, pressure, density, and temperature increment, DT-Continued

ID	Temp K	Press bar	Den mol/l	DT K	DQ/DT J/K	Co J/K	Cl J/mol·K	C_V J/mol · K
1109	127.100	275.451	26.559	4.981	126.527	59.056	1.574	33.180
1105	127.123	275.769	26.558	5.028	126.592	59.064	1.574	33.210
1004	102.424	48.414	27.388	5.069	121.472	49.858	1.475	34.428
1001	105.029	90.948	27.371	5.078	122.552	50.974	1.619	34.267
1005	107.466	129.912	27.355	5.035	123.275	51.986	1.613	34.129
1002	110.058	170.735	27.338	4.981	124.205	53.030	1.637	34.049
1006	112.446	207,806	27.322	4.941	125.126	53.962	1.646	34.035
1003	115.142	249.013	27.305	4.914	126.082	54.979	1.652	33.999
1007 1912 1901 1907 1902	92.592 92.609 93.793 95.465	282.491 40.274 40.540 62.384 92.859	27.290 28.164 28.164 28.155 28.143	4.903 3.061 2.871 2.873 2.842	126.695 120.491 120.603 121.008 122.072	55.789 45.311 45.319 45.899 46.701	1.673 1.351 1.313 1.458 1.769	33.879 35.326 35.415 35.186 35.003
1913	95.634	95.885	28.141	3.022	122.178	46.780	1.765	35.020
1908	96.675	114.525	28.134	2.824	122.424	47.269	1.769	34.898
1903	98.301	143.313	28.122	2.807	123.144	48.020	1.740	34.913
1909	99.505	164.435	28.114	2.821	123.531	48.566	1.745	34.830
1904	101.123	192.506	28.102	2.793	124.316	49.288	1.768	34.839
1910	102.319	213.085	28.093	2.791	124.573	49.812	1.767	34.710
1905	103.902	240.032	28.082	2.749	125.401	50.495	1.755	34.793
1911	105.104	260.314	28.074	2.766	125.538	51.005	1.766	$34.600 \\ 34.644$
1906	106.655	286.252	28.063	2.751	126.307	51.653	1.781	

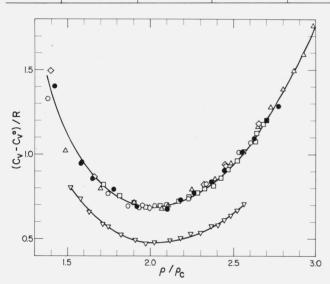


FIGURE 6. Reduced specific heats versus reduced density for CH₄), $F_2(\langle \rangle)$, $O_2(\Delta)$, $Kr(\square)$, $Ar(\bigcirc)$, and $Ne(\nabla)$.

Comparison of C_V methane extrapolated to saturation to several other liquids: F_2 [8], O_2 [6], Kr [13], Ar [14], and Ne [15] is shown if figure 6. The density is reduced by the critical density. The spectroscopic heat capacity, C_v^0 is subtracted in each case. Molar specific heats are independent of reducing parameters [16]. All of the data except that for Ne correlate quite well. Presumably this departure of Ne is a result of its being more of a quantum fluid. H2 and He also depart markedly from this grouping as shown by Diller [16].

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5. References

- [1] The S. I. (international system) unit of pressure is the Pascal (1 Pa = 1 N/m²). The bar is 10^5 Pa, also 1 atm = 1.01325×10^5 Pa, 1 lb/in²=6894.757 Pa, 1 dyne/cm²=10⁻¹ Pa. Also one mole methane = 16.0430 g, based on the ¹²C scale and the natural isotopic abundance averages: see Remy, H., Chem. Berichte 101, I (1968).
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